



Cornell University

Follow the Sun through the Clouds: Application Migration for Geographically Shifting Workloads

Zhiming Shen

Cornell University

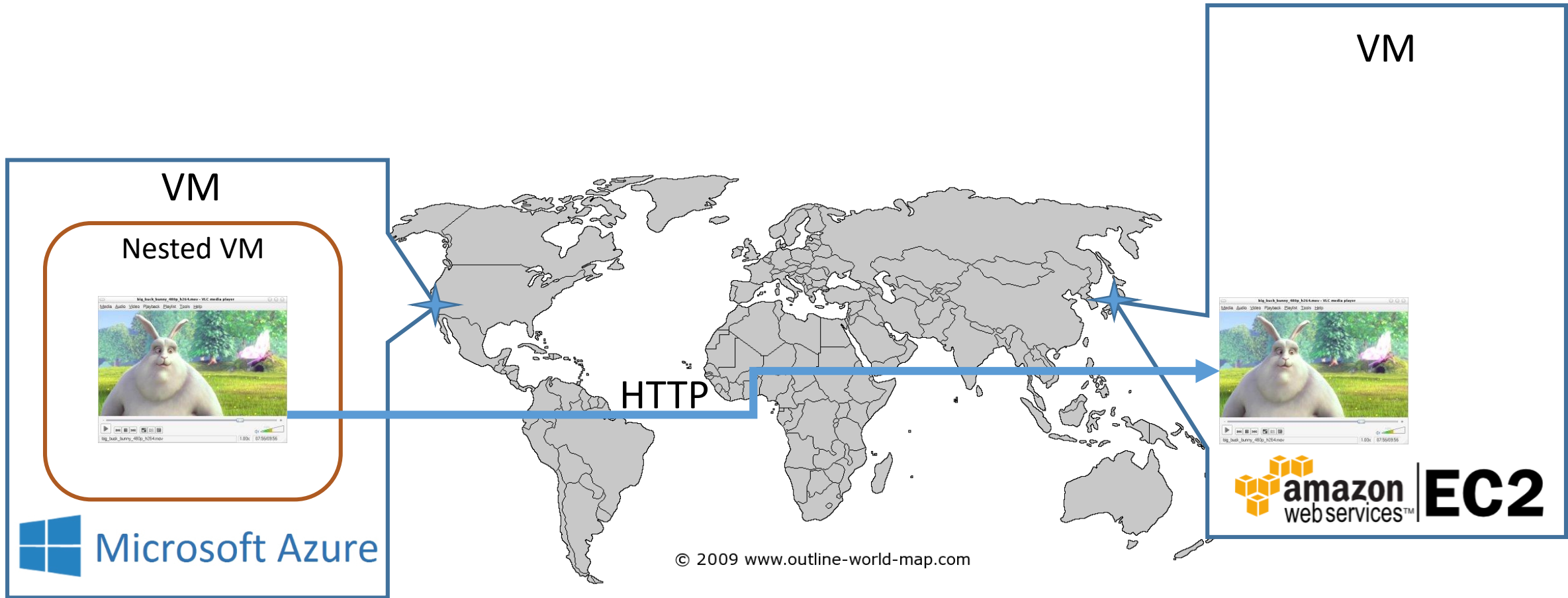
Joint work with Qin Jia, Gur-Eyal Sela, Ben Rainero, Weijia Song,
Robbert van Renesse, Hakim Weatherspoon

Supercloud Demo



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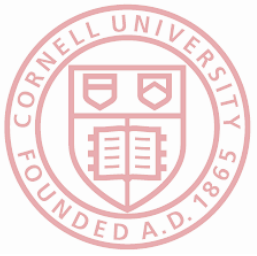
Supercloud Demo



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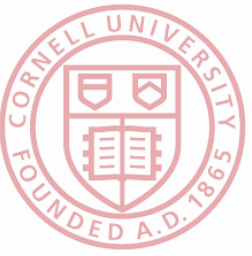
Supercloud Demo





Highlights

- Automatic VM placement and migration
- Migrated VMs are LIVE
- IP addresses are not changed
- TCP connections are not broken

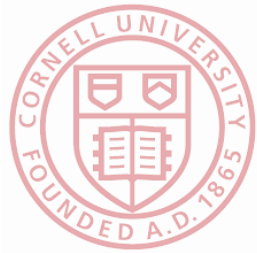


Demo (Full video available at <http://supercloud.cs.cornell.edu>)

The screenshot displays a VNC viewer interface with several windows:

- Microsoft Azure VMs:** A grid of virtual machines, each with a blue desktop background and the Microsoft Azure logo. A yellow circle highlights one of the VMs.
- Amazon EC2 VMs:** A vertical stack of virtual machines, each with a white desktop background and the Amazon EC2 logo.
- Ubuntu VM:** A virtual machine with a blue desktop background and the KDE logo.
- Terminal Window:** A terminal window showing a shell prompt: `[root@centos6 scheduler]#`.
- PowerPoint Slide Show:** A slide titled "Demo" showing a world map with callouts for "Microsoft Azure" (pointing to North America) and "amazon EC2" (pointing to Asia).

At the bottom of the screen, there is a status bar with the text "RECORDED WITH SCREENCAST MATIC" and "SLIDE 1 OF 2".



Full Demo (<http://supercloud.cs.cornell.edu>)

The screenshot displays a multi-monitor VNC environment with four main windows:

- Top Left:** A browser window titled "Locate IP Address Lookup Show on Map City of the IP 13.81.108.64 - Mozilla Firefox". It shows a map of Europe with Amsterdam, Netherlands highlighted. Below the map is a table with IP details:

IP Address	City	Country Flag	DMA
13.81.108.64	Amsterdam W		n/a
Provider	State (Code)	Latitude	Area
Microsoft Corporation	Noord-Holland (07) W	52.35	n/a
Hostname	Country	Longitude	Posta
13.81.108.64	Netherlands W	4.9167	1001

- Top Right:** A browser window titled "Locate IP Address Lookup Show on Map City of the IP 52.236.0112". It shows a map of Asia with Tokyo, Japan highlighted. Below the map is a table with IP details:

IP Address	City	Country Flag	DMA
52.236.0112	Tokyo, Japan		n/a
Provider	State (Code)	Latitude	Area
Amazon.com, Inc.		35.68	n/a
Hostname	Country	Longitude	Posta
ec2-52-69-55-209.ap-northeast-1.compute.amazonaws.com	Japan	139.76	1001

- Bottom Left:** A browser window titled "Locate IP Address Lookup Show on Map City of the IP 104.198.0.17 - Mozilla Firefox". It shows a map of the United States with Mountain View, United States highlighted. Below the map is a table with IP details:

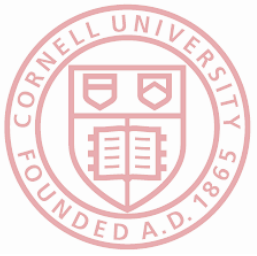
IP Address	City	Country Flag	DMA
104.198.0.17	Mountain View W		n/a
Provider	State (Code)	Latitude	Area
Google Inc.	California (CA) W	37.4192	n/a
Hostname	Country	Longitude	Posta
17.0.198.104.bc.googleusercontent.com	United States W	-122.0574	1001

- Bottom Right:** A browser window titled "Locate IP Address Lookup Show on Map City of the IP 128.84.8.211 - Mozilla Firefox". It shows a map of the United States with Ithaca, United States highlighted. Below the map is a table with IP details:

IP Address	City	Country Flag	DMA
128.84.8.211	Ithaca W		n/a
Provider	State (Code)	Latitude	Area
Cornell University	New York (NY) W	42.4455	n/a
Hostname	Country	Longitude	Posta
euca-128-84-8-211.instances.redcloud.cac.cornell.edu	United States W	-76.4804	1001

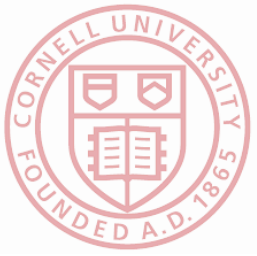
Other elements in the environment include:

- Backgrounds:** The desktops feature repeating logos for Microsoft Azure (top left), Google Cloud Platform (bottom left), and red cloud (bottom right).
- Performance Graphs:** A window titled "TigerVNC: QEMU (ubuntu--incoming)" displays four network speedometer graphs showing latency and throughput for connections to azure, amazon, google, and redcloud.
- System Information:** The taskbars show the user is 'root' and the date is 'Fri Sep 23, 8:44 PM'.



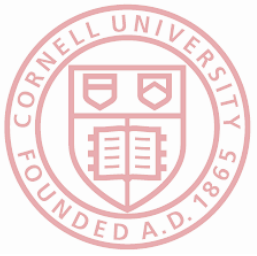
Highlights

- Automatic VM placement and migration
 - Migrated VMs are LIVE
 - IP addresses are not changed
 - TCP connections are not broken
-
- Appears as a unified private cloud that spans all clouds
 - Controlled by the user!



Research Challenges

- How to migrate across incompatible virtualization platforms?
- How to keep IP addresses unchanged and TCP connections unbroken?
- How to decide when and where to migrate?
- How to make the system efficient?

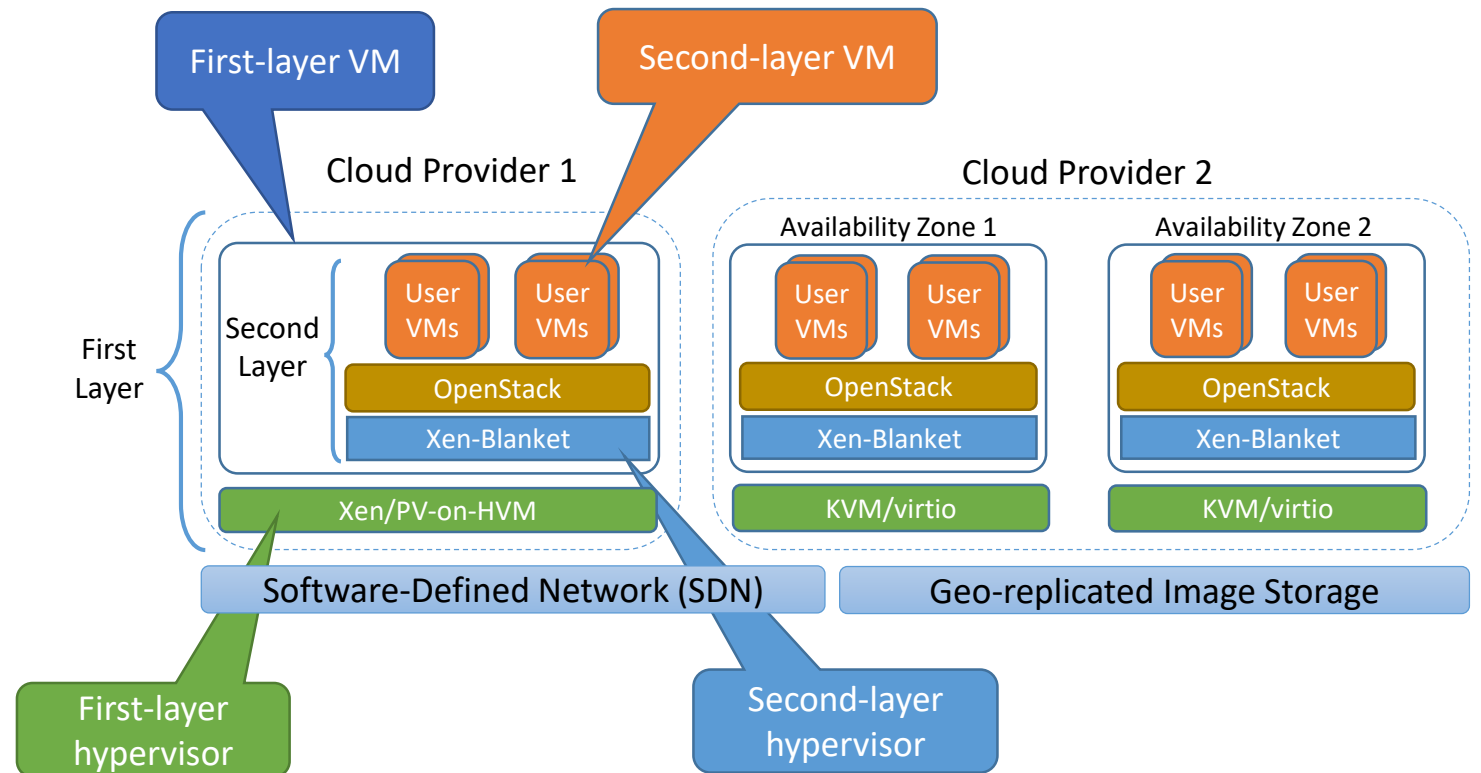


Supercloud is the first system that supports
automatic,
efficient,
and live
VM migration

across heterogeneous cloud providers
without changing IP addresses
or breaking TCP connections.

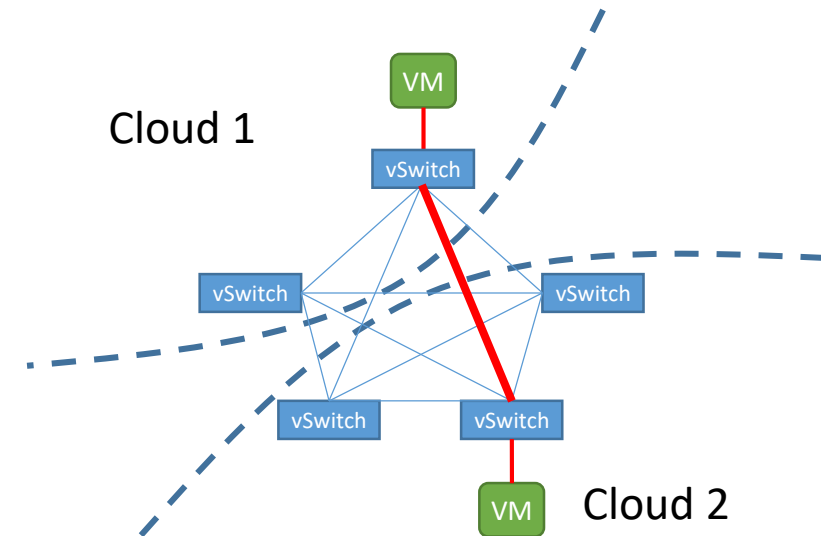
Supercloud Architecture

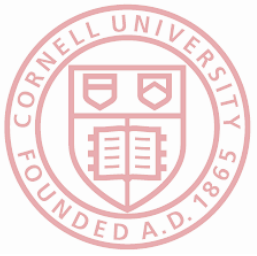
- Computation
 - Nested hypervisor: Xen-Blanket
 - Support all major platforms
- Network
 - SDN overlay
 - Support migration with public IP
- Storage:
 - Geo-replicated storage
 - Optimized for serving VM images
- Resource management
 - OpenStack platform
 - Automatic scheduling framework



Supercloud Networking

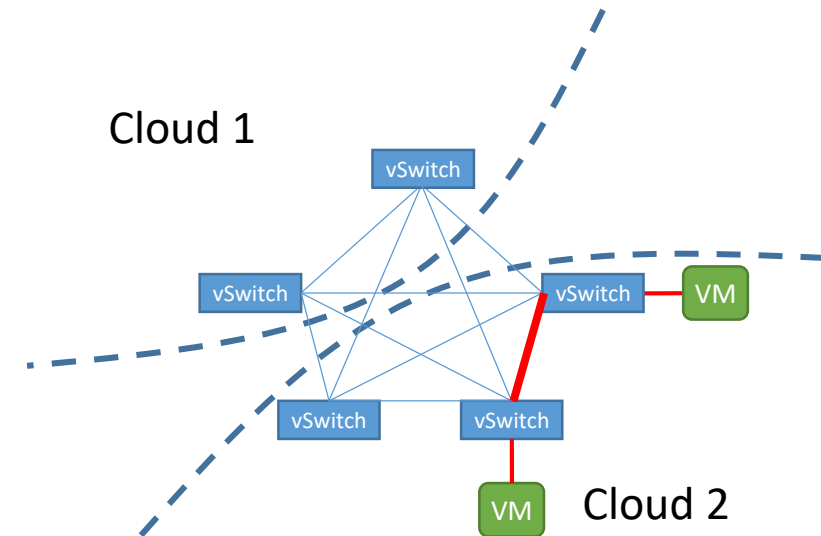
- Challenges:
 - Optimal routing without extra forwarding
 - Migration without changing IP addresses
- Solution:
 - VPN overlay with full-mesh tunnels
 - Frenetic SDN controller



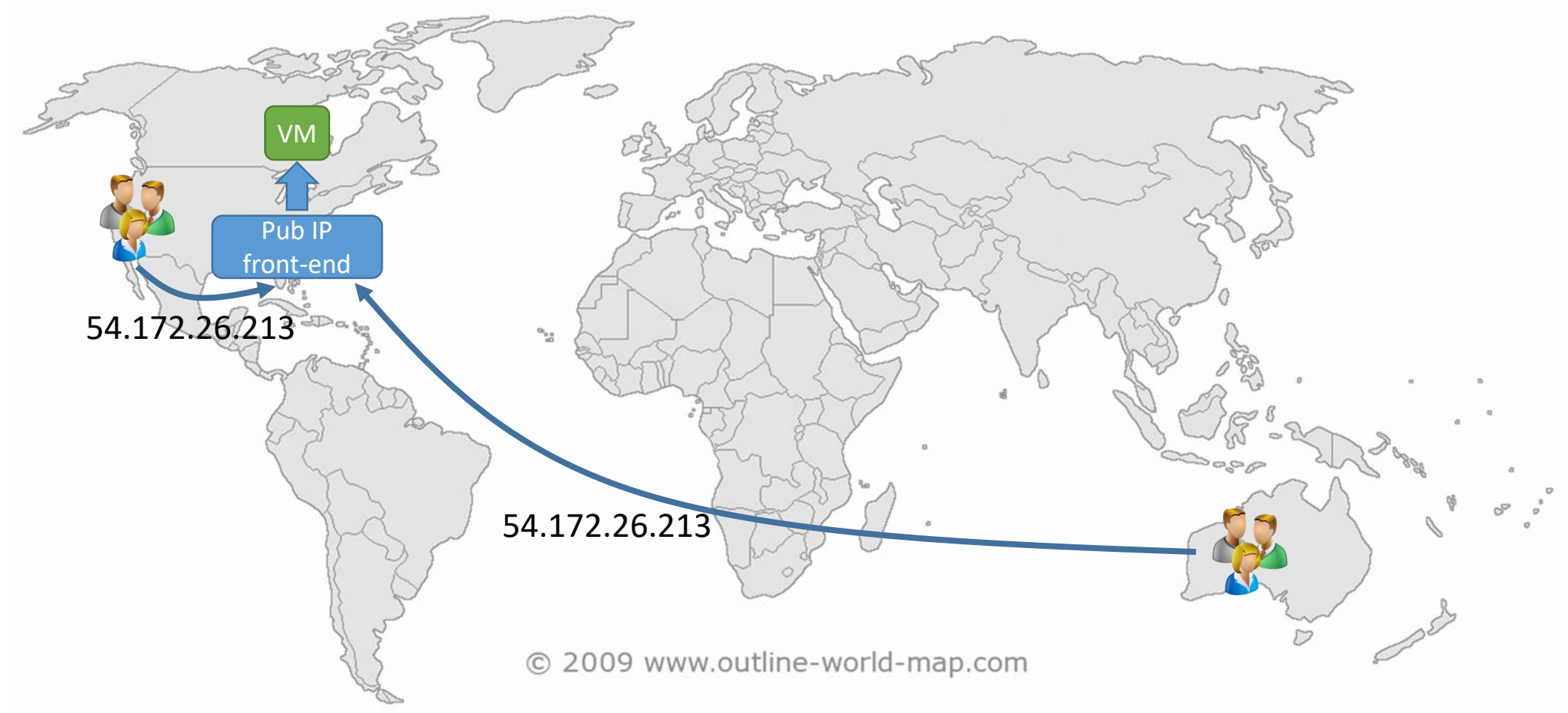


Supercloud Networking

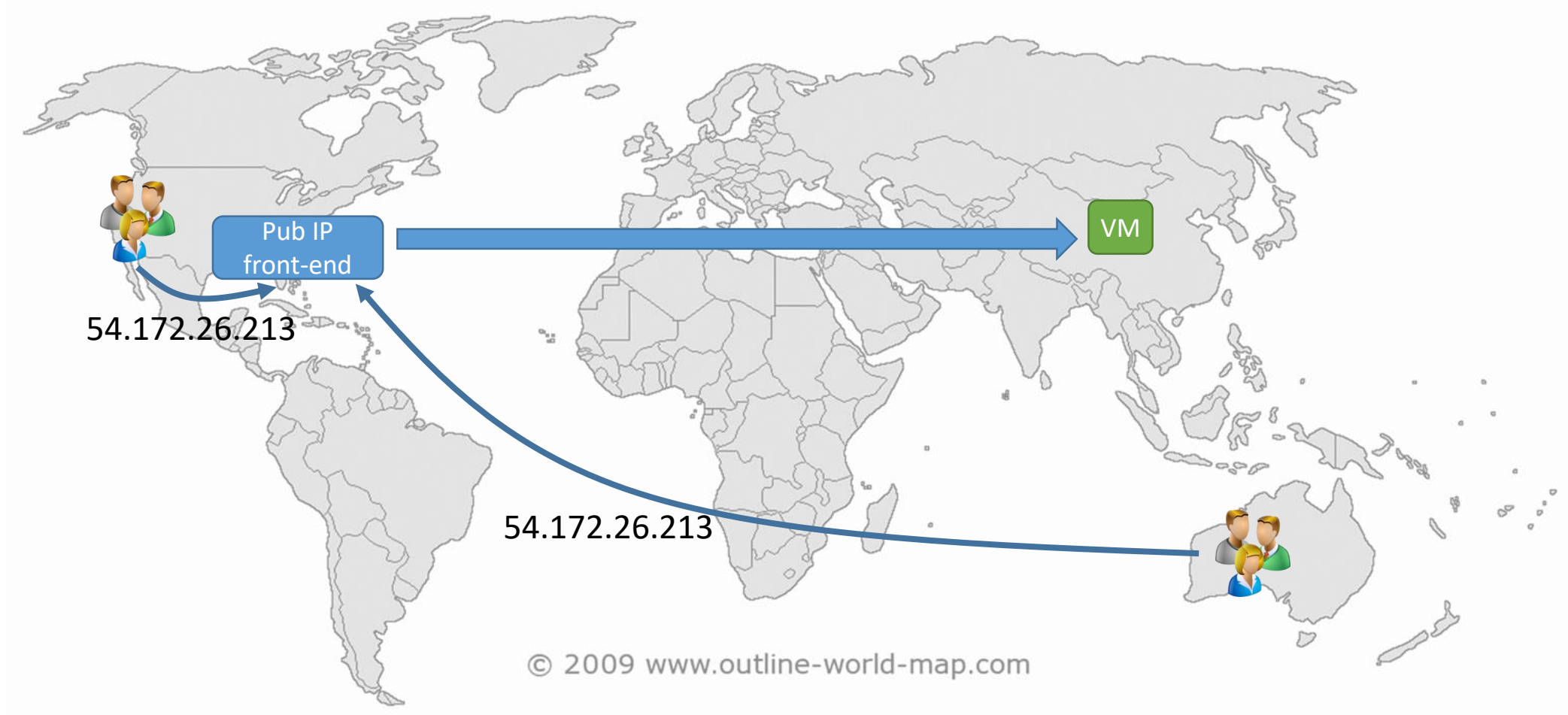
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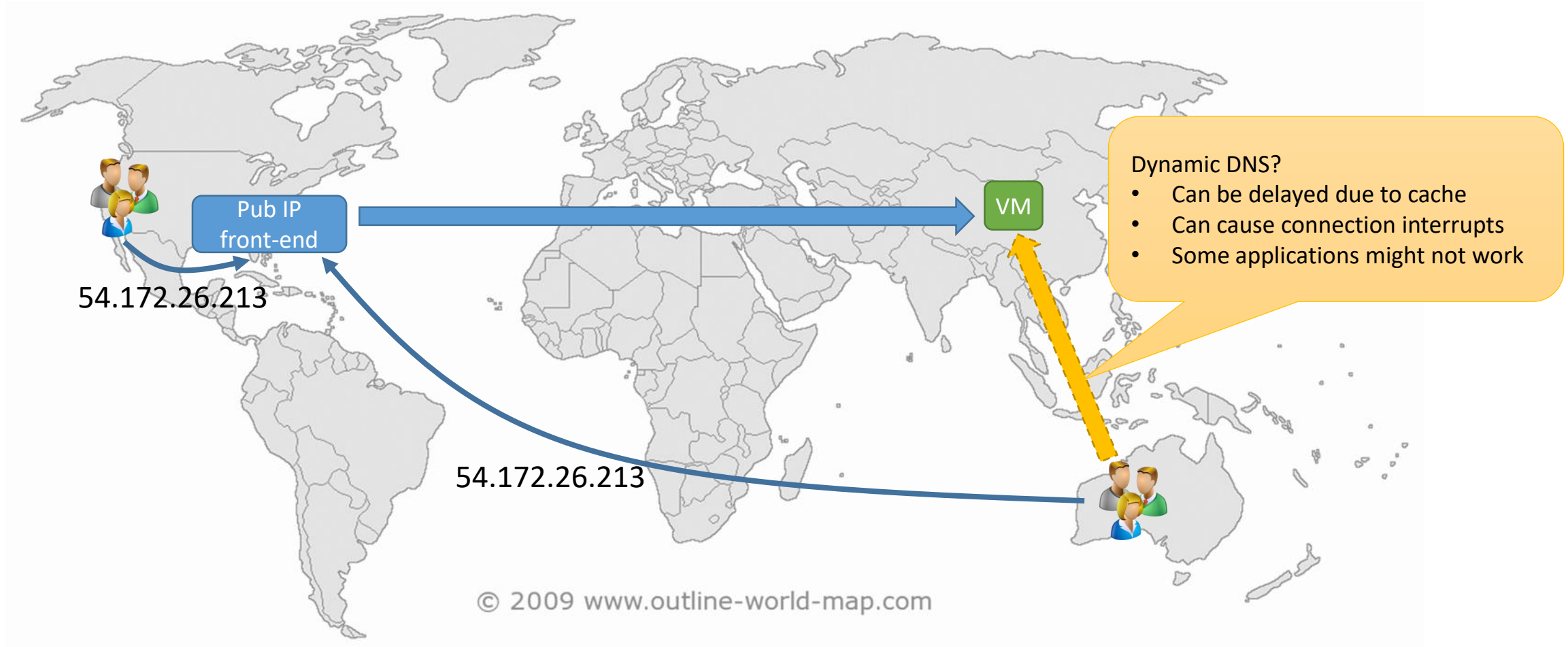
VM Migration with Public IP Address



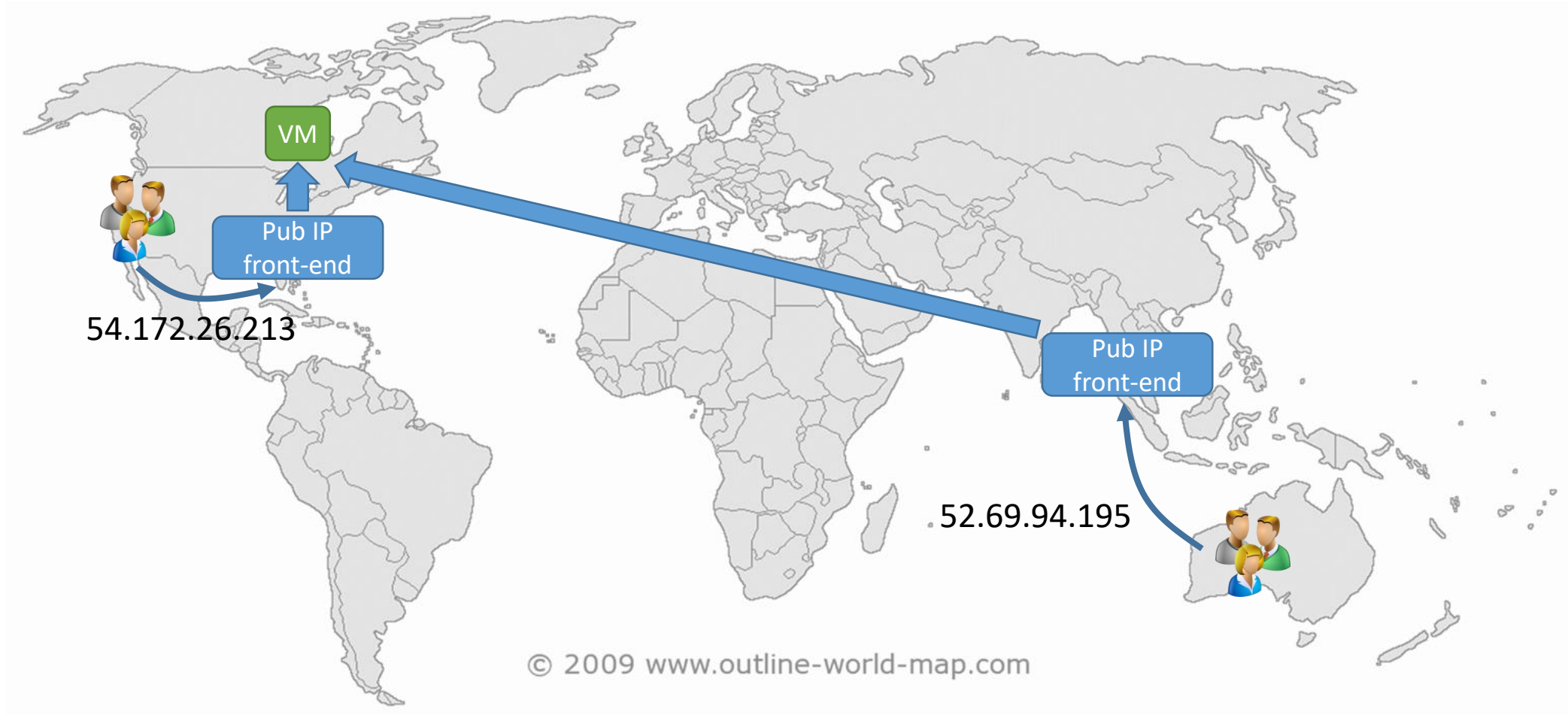
VM Migration with Public IP Address



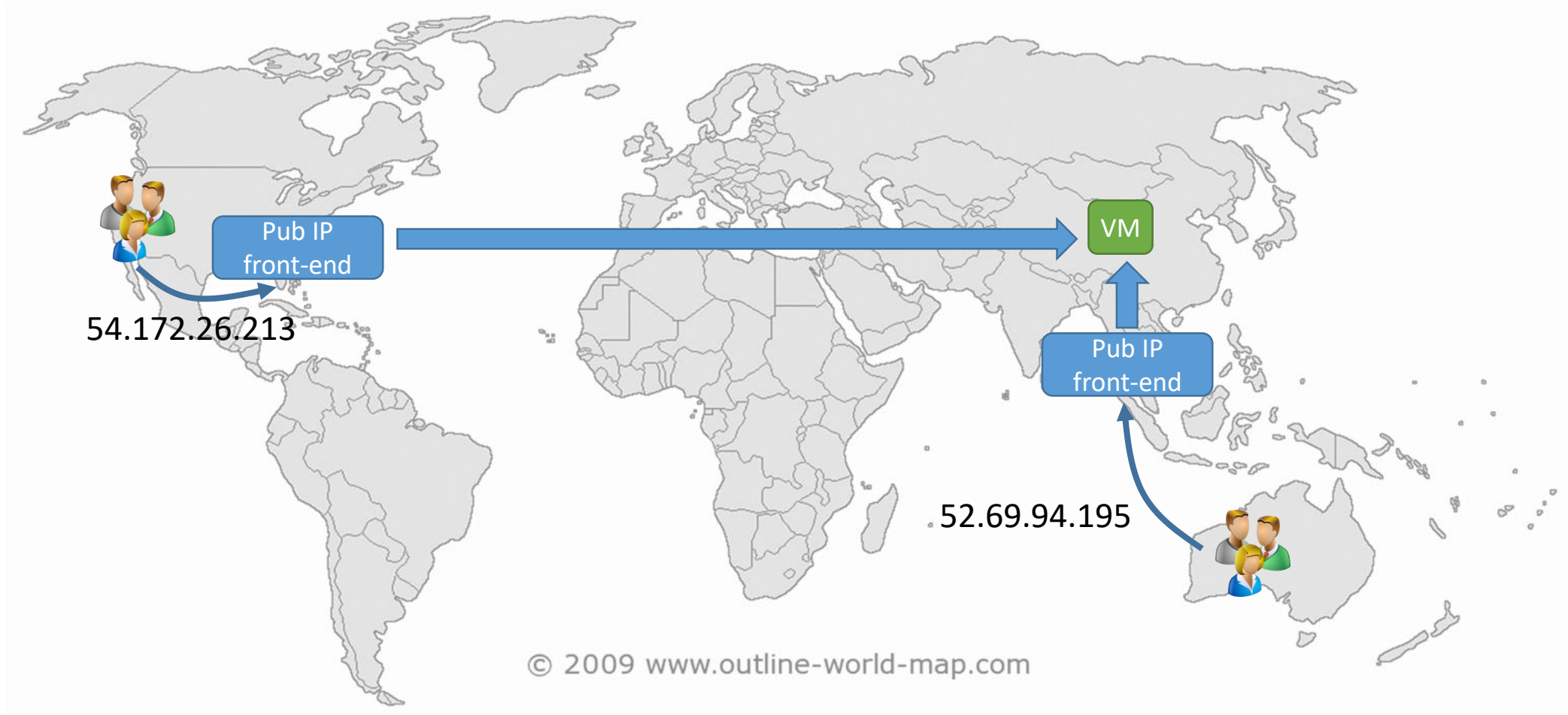
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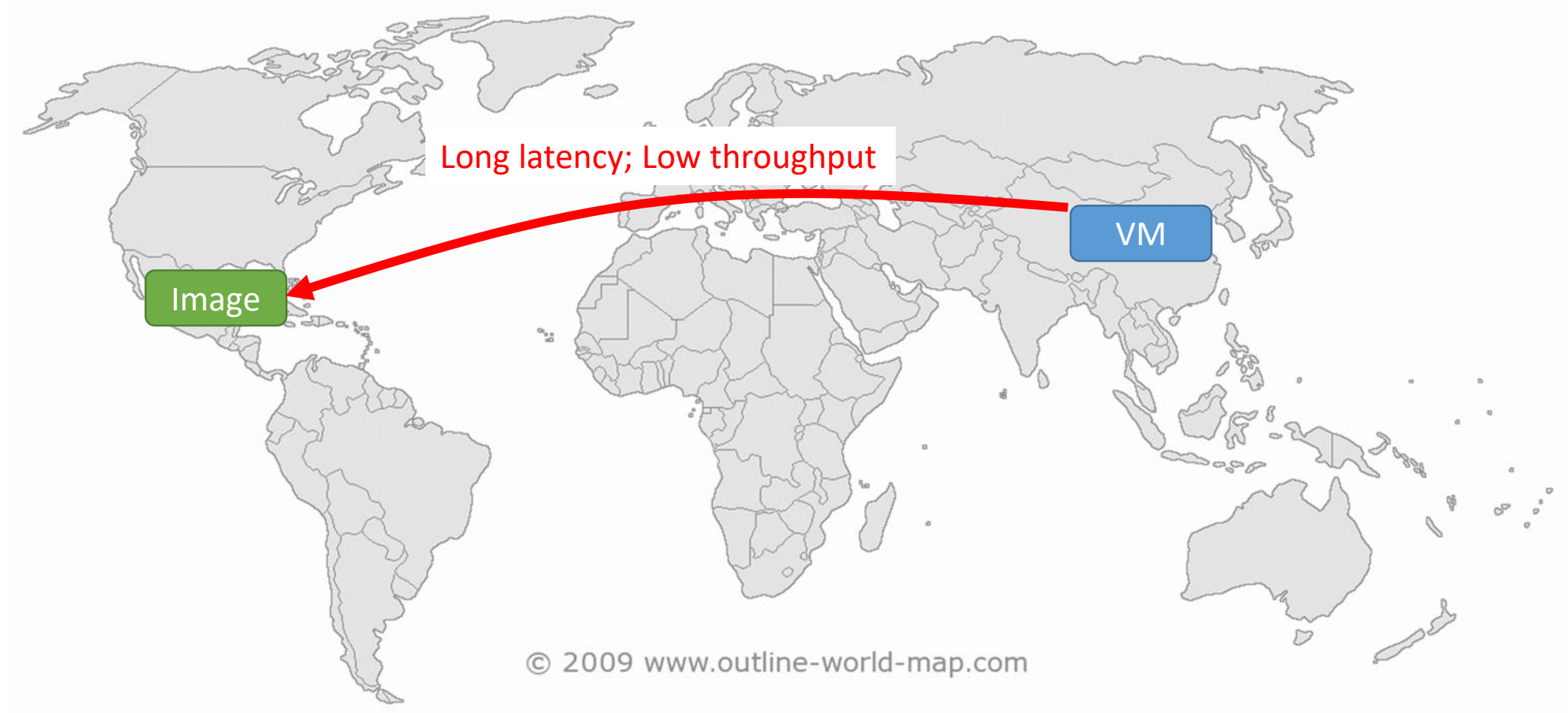
VM Migration with Public IP Address



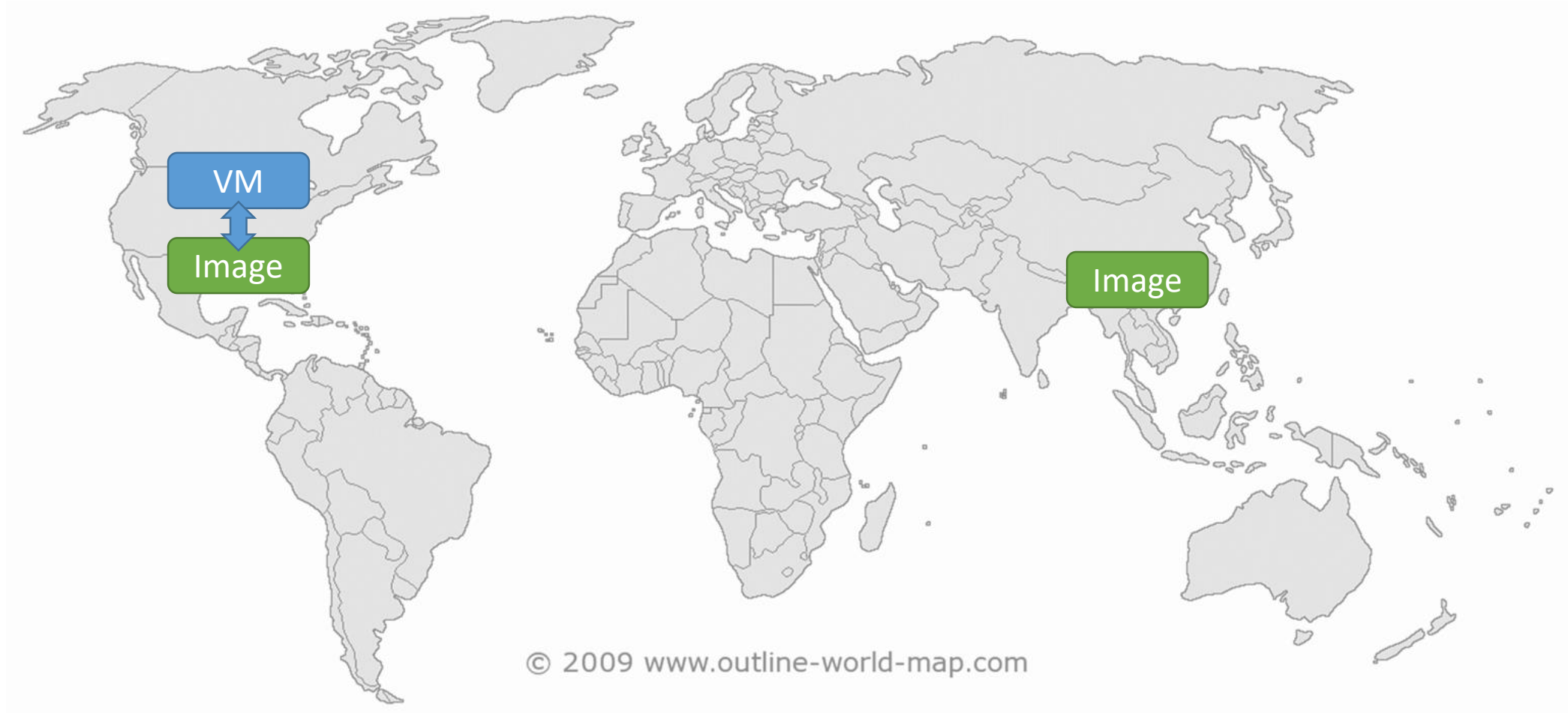
VM Migration with Public IP Address



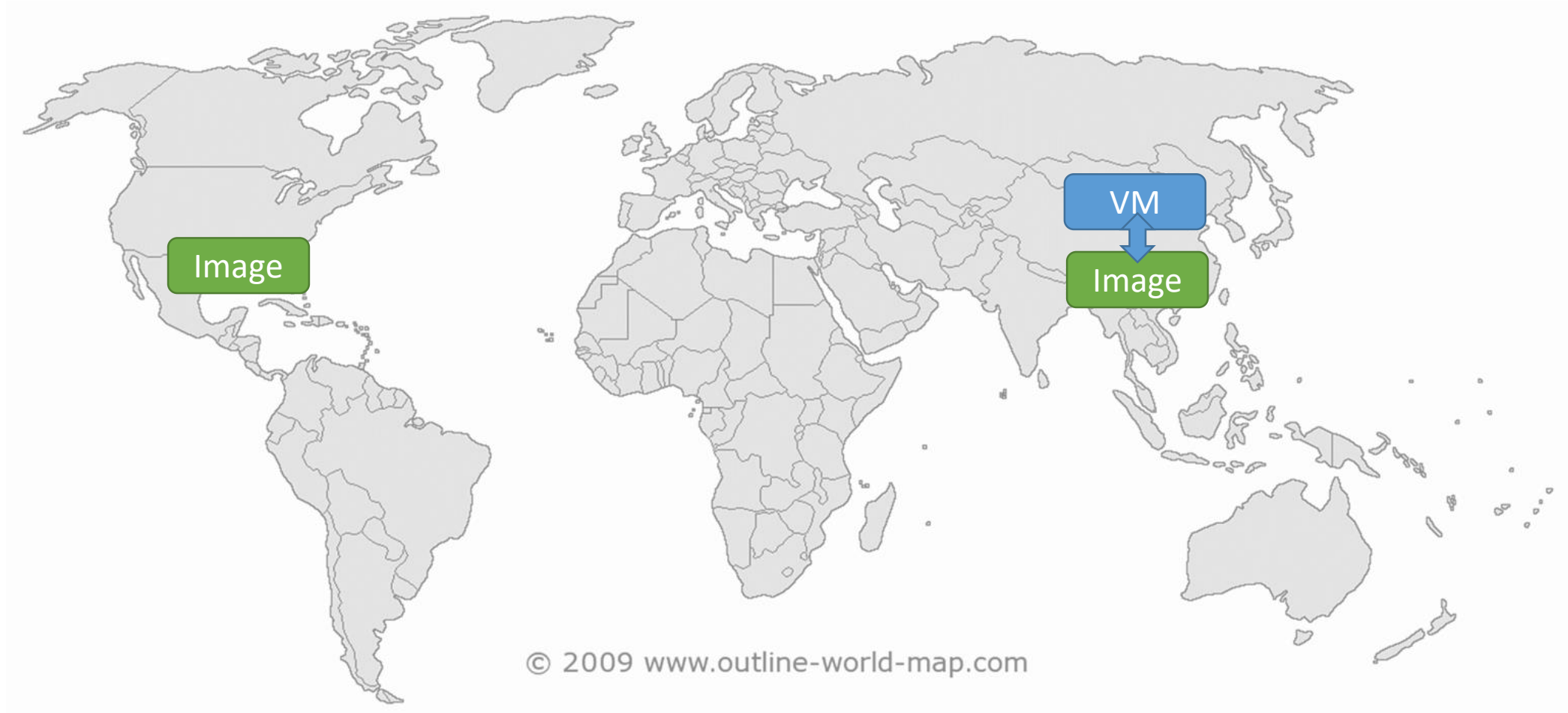
Centralized VM Image Storage



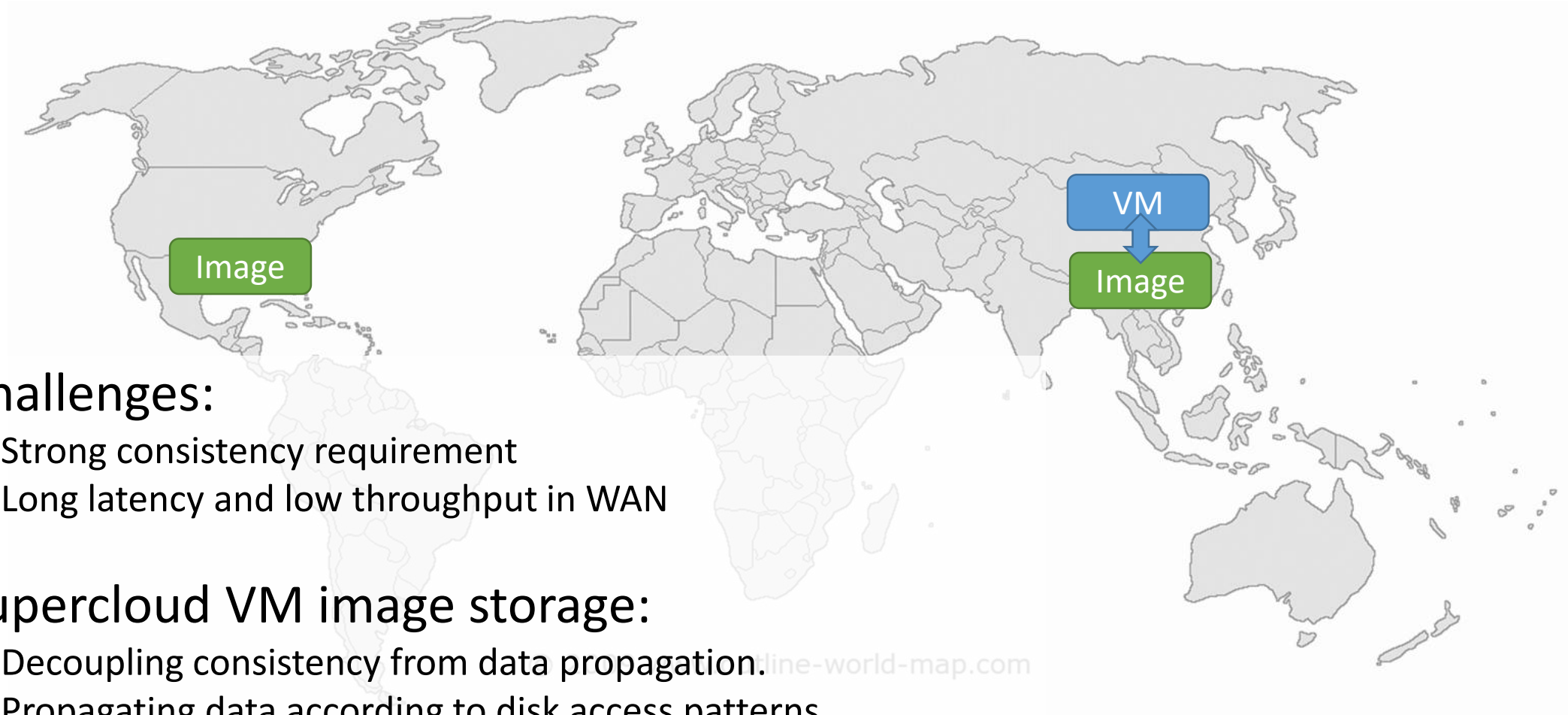
Geo-Replicated VM Image Storage



Geo-Replicated VM Image Storage



Geo-Replicated VM Image Storage

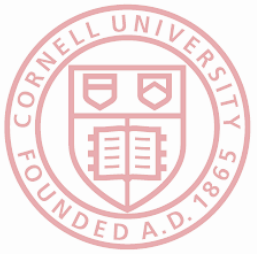


Challenges:

- Strong consistency requirement
- Long latency and low throughput in WAN

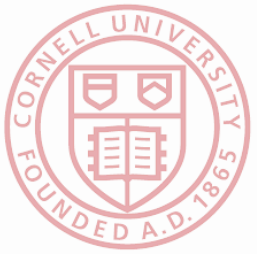
Supercloud VM image storage:

- Decoupling consistency from data propagation.
- Propagating data according to disk access patterns.



In the Paper

- Comparison with application-level migration
- Placement policies for different types of applications
- Detail design of the image storage
- Hierarchical network topology
- Evaluations



Conclusion

- Supercloud: application migration for geographically shifting workloads
 - Crossing heterogeneous cloud providers
 - Automatic placement and migration
 - Geo-replicated image storage
 - Wide-area SDN
- A unified private cloud that spans all clouds
- Controlled by the user!
- More at <http://supercloud.cs.cornell.edu>

Thank You.
Questions?